IMPROVEMENTS IN THE LONGWORTH POWER-HAMMER.

By MR. ERNEST SAMUELSON, *Member, of BANBURY.*

Whilst economy in power is engrossing the attention of all who are engaged in the manufacturing interests in this and other countries, and the tendency is to concentrate steam power in one spot, and convey its energy either by means of electrical power or by shafting and belts, or by a combination of both, to the tool, we are brought to the consideration of, amongst other things, the advantage in the use of Power-Hammers in place of Steam-Hammers; and as this subject has not been before the members of this Institution since 1882, when Mr. D. Longworth read a Paper* describing a hammer in which the blow was rendered variable by means of a movable fulcrum, the author has thought that a short description of some further improvements upon this design of hammer may be of interest to the members.

In 1891 the author's attention was directed to Mr. Longworth's patent of the previous year, and, being struck with the advantages of the principle upon which he had improved his hammer, entered into an arrangement with him for the manufacture of the same, and the various drawings here presented serve to illustrate these improvements, and the principle upon which the hammers are now built. They form a distinct departure from all previous modes of construction, as instead of varying the intensity of the blow by means of a movable fulcrum or frictional brake upon some of the moving parts of the

* Proceedings, 1882, page 204.

hammer, it is regulated by means of a cushion of air rendered variable in volume under the piston in a controlling cylinder in a simple manner, by means of an air-valve under the control of the attendant.

Fig. 1.

Fig. 1 is a sectional view which serves to illustrate the principle upon which the hammer is built. It will be seen that the hammer consists of the usual piston, piston-rod, and tup, but the piston-rod is prolonged upwards, and carries a supplementary or second piston working in a second cylinder. The lower cylinder merely acts as a "controlling" cylinder for regulating the intensity of the blow, which is effected by means of a series of air-ports communicating with the lower cylinder and the outside atmosphere, which ports can be opened or closed one or more at a time by a simple cylindrical plug valve, under the control of the attendant, by means of a hand or foot-lever, Fig. 2, Plate 5. The top piston works in a second or "actuating" cylinder freely in a vertical line, and a double series of air-holes communicating freely with the atmosphere is

drilled round this cylinder to regulate the cushion of air in the same, according to the nature of the work to be done under the hammer, and to prevent the piston striking the covers; this cushion

also assists in intensifying the blow, and in lifting the tup on its upward stroke. The upper or "actuating" cylinder is connected by means of a crosshead, with two side links, to one end of a rocking lever working upon a fixed fulcrum, whilst the other end of this rocking lever is connected to a crank by a connecting-rod.

Thus, when the crank is put in motion, the rocking lever raises the side links, and with them the upper cylinder, until the top piston cuts off the air at the bottom row of holes in same, and, this air becoming compressed by the cylinder still continuing to rise, eventually lifts the top piston with it, and thereby the piston-rod and tup. Upon the crank passing the bottom of its stroke, the top cylinder gains upon the falling piston and tup until it closes the communication of the air through the top row of holes, after which this air is compressed, and the motion of the falling piston and tup is thereby accelerated. If now the lower cylinder is in free communication with the atmosphere through its bottom air-ports, the tup will fall to its lowest point, viz., the face of the anvil, and the full force of the blow will be struck; but if all these air-ports are closed, the lower piston will compress the air in the bottom of the controlling cylinder, until that pressure is sufficient to sustain the falling weight, and the tup will be prevented from striking the anvil.

Small self-acting air-valves in the bottom cylinder allow air to be drawn in by the lower piston on its upward stroke when necessary to restore atmospheric equilibrium; these however remain at rest when the lower cylinder has free atmospheric communication through the lower ports. The top of the lower cylinder remains in free communication with the atmosphere at all times. The cylindrical air-valve is under the control of the attendant by means of a suitable system of hand or foot-levers, Plates 5-8, and is kept in its normal position covering the whole of the air-ports to the lower cylinder by means of a spring, as shown on Figs. 3 and 4, Plate 6; and when the hammer is started, the piston works upon an air-cushion, as explained, and the work can be readily introduced upon the anvil. By opening one or more of these air-ports, the air-cushion in the lower cylinder is regulated and

the force of the blow controlled, and by rapidly opening and closing them again, the attendant can deliver single blows upon his work—this of course being contingent upon the thickness or height of the iron being less than the clearance between the tup and anvil when the hammer is running upon its greatest air-cushion, which can be allowed for in the designing of the hammer to suit particular work. The speed and stroke of the hammer can be varied to suit different classes of work; thus, for riveting or cutlers' work, Plate 7, a quick speed and short stroke can be maintained, whilst for general forging or stamping, Plates 6 and 8, a long stroke and moderate speed is obtainable, which enables the attendant to move or handle his heat on the anvil.

Owing to the comparative length of the side links, the versed sine of the arc through which the end of the rocking lever moves affects but slightly the true vertical motion of the top cylinder, and the tendency to wear sideways is reduced practically to a negligible quantity by being guided in a long neck or gland on the top portion of the piston rod in the earlier design. The lower or main piston-rod is similarly guided in another long neck on the lower cylinder, and the tup is placed between side guides where a hammer of this type is required, as in Fig. 13, Plate 8. In order to reduce the total height and to better guide the top cylinder, the author has more recently brought this cylinder down to work inside the controlling cylinder, Plate 5, making the top cover serve as a guide, thus relieving the piston-rod of that function, the links being journalled on pins formed on the top cylinder cover, see Figs. 2, 3, and 4.

In the earlier design the wear of the tools was provided for by the cross-head being adjustable upon the top cylinder gland, see Fig. 1 (page 100), whilst in the later design, the connecting rod to the crank is made so that it can readily be lengthened or shortened as shown in Plate 5, the proper position of the top cylinder relative to the anvil being, when the faces of the tool are touching each other, and the front end of the rocking lever is at the lowest point of its stroke, the bottom of the piston in the top air-cylinder should just cut off or close the bottom row of holes in same. The working cylinder being so far removed from the work upon the anvil, no danger is incurred from grit or heat affecting it.

Fig. 5, Plate 6, illustrates the acceleration of the actuating cylinder due to the position of the crank and rocking lever in a 3-cwt. single standard hammer. The uniform speed of the crank being 5.88 feet per second, the speed of the rocking lever, and with it the actuating cylinder and tup, is accelerated on the down stroke to about 9.5 feet per second at mid stroke.

Figs. 6 and 7, Plate 7, show a different form of drive adopted for the smaller sizes of hammer, such as for riveting work, the movement being obtained by means of a crank and a slide block on the top of the cylinder cover; but this form is not recommended for the larger sizes and heavier work.

Figs. 8 and 9, Plate 7, show a hammer designed for planishing where the blow is regulated by means of a movable fulcrum. This hammer is fitted with a rocking lever similar to Longworth's earlier arrangement (Proceedings 1882, Plates 28 and 29), and a ready means of regulating the blow when the hammer is at rest is found to suffice, instead of adding the additional parts of the controlling cylinder, &c.; because in this class of work, when once the strength of the blow is determined upon, it remains constant, and can be stopped by means of belt shifting-gear. The controlling cylinder however can be fitted to this class of hammer if desired, when the movable fulcrum is dispensed with, and a rocking lever of similar type to the other hammers is used.

Figs. 10 and 11, Plate 8, illustrate a hammer specially designed for welding boiler flues, the flues being carried on any suitable saddle, such as are used in boiler shops; and a special advantage is obtained in the use of such a hammer in this class of work, because of the uniformity in the number of blows per minute. Thus when the first few heavy blows are given, the lighter ones which follow to finish the work are delivered at the same speed, and the fullest advantage is taken of the heat, whereas in a steam-hammer when the lighter blows are delivered a reduction ensues in the number per minute.

Figs. 12 and 13, Plate 8, illustrate two further types of framing for general smiths' work.

The power required to drive the hammer is proportionate to the work being obtained from same, for when the hammer is running upon its full cushion of air in the controlling cylinder, the

compressed air assists in raising the tup on its upward stroke, and a minimum power is required. This increases as the blow is intensified until no cushion exists, and the full blow is given. Fig. 14, Plate 9, shows the power absorbed by a 3-cwt. hammer when running light, and when delivering the fullest blow; these were taken from a steam-engine connected through a countershaft to the hammer, the actual power absorbed being 3.1 and 8.7 I.H.P. respectively, after deducting the friction of the engine, shafting, &c. Fig. 15 shows cards taken from the top and bottom of the actuating cylinder of the same 3-cwt. hammer, and from the controlling cylinder when one air-port is open down to the position where all are open, and the hammer is giving its fullest blow.

Fig. 16 represents cards taken from a 4-cwt. steam-hammer, having 8-inch cylinder with 16 inches stroke, which shows the wasteful power expended in tools of this class, for whilst about 64 lbs. of water are required per I.H.P. per hour to work this hammer from the calculations as below, a fairly economical engine should not use more than about, say, 20 lbs., and it is in this respect that the advantage of a Power over a Steam-Hammer is most evident.

Water consumption of 4-cwt. steam-hammer as taken from cards on Fig. 16, the average pressure at end of stroke being 15 lbs. above atmosphere:—

Cylinder, 8 inches diameter $\times$ 16 inches stroke.

Number of blows per minute, 120.

Thus $50 \times 16 \times 120 \times 2 = 192,000$ cubic inches, or the volume of steam used per minute.

Specific volume of steam at 30 lbs. absolute = 838.

Thus $\frac{192,000}{838} = 229$, or the cubic inches of water used per minute,

and $229 \times 0.036 \times 60 = 494$, or the lbs. of water per hour.

The I.H.P. being 10, as taken from the cards, the water used per I.H.P. per hour = 49.4, to which must be added a liberal allowance for condensation in the cylinder and steam-pipes, say 30 per cent., which would make the consumption of water = 64 lbs. per I.H.P. per hour.

The Author exhibited the 3-cwt. Power-Hammer shown on Plate 4, and also two specimens of mild steel discs, each of which had been flattened at one heat under a similar hammer, from a cylinder 2 inches diameter by 2 inches long; they now roughly

measured 6 inches diameter by $\frac{1}{8}$ inch thick. A piece of high class tool steel was shown after being drawn down under the same hammer; it measured 2 feet 6 inches long by $\frac{3}{4}$ inch square, its original size having been 5 $\frac{1}{2}$ inches long by 1 $\frac{3}{4}$ inches square. A piece of cast steel was also shown drawn down from 1 $\frac{3}{4}$ inches square under a 4-cwt. steam-hammer in one heat, the original length having been 5 $\frac{1}{2}$ inches now measured 40 inches long by $\frac{5}{8}$ inch square. The 1-lb. riveting hammer shown on Plate 4 was also exhibited, together with a sample of cycle roller-chain riveted by the Albert Eadie Chain Co., of Redditch, with this hammer, which was riveting 450 feet per working day of 10 hours, as against 100 to 112 feet formerly by hand, the rivets being $\frac{1}{8}$ -inch and $\frac{1}{2}$ -inch pitch.

The Paper is illustrated by the Figure in the text and by Plates 4 to 9, which are reproduced from the author's drawings and from the machinery shown at the Meeting.

Discussion on 22nd February.

The CHAIRMAN asked Mr. Samuelson if he would like to add any remarks before the discussion commenced.

Mr. SAMUELSON thought it would be better to let members raise any points in the course of discussion, to which he could then reply. The section, Plate 5, showed plainly the principle on which the hammer was built, and was simple and intelligible, and therefore he would not waste the time of the meeting at that moment.

The CHAIRMAN said that he hoped that any of the members present, who had had practical experience with the use of the machines, would take part in the discussion. If they had any criticisms to make, or any admiration to express for the tools, it would

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be pleasant to the author of the Paper to hear any appreciative remarks. If there were any defects to find in them arising from actual practice, it would of course be more valuable to the members to hear those observations than merely theoretical criticisms on the mechanism. There might also be present those who had tried other makes of machines of power-hammers and pneumatic tools, and they might be able to say something about the conditions under which the one make or the other make could be applied most favourably. In addition to that he thought it would be quite fair for anyone who had had experience of a power-hammer and of steam-hammers to give an opinion as to where the advantages of a steam-hammer came in, because the Paper had challenged that by alluding to steam-hammers, and to the consumption of steam used in them, as well as to other points of difference between the steam-hammer and the power-hammer. Similarly to that, it would be quite suitable for anyone who had had experience in using electric drills, as well as pneumatic drills, to furnish some information about them. He did not suggest bringing in those outside comparisons from a purely theoretical point of view, but it would be extremely valuable if anyone had used both systems to hear the results of his preference.

The SECRETARY called attention to three diagrams on the wall that were not referred to in the Paper. Two of them illustrated Mr. Waterhouse's compressed-air forge-hammer, described in a Paper read by Mr. Charles Beyer in 1858.* The other drawing was by Mr. David Joy of a power-hammer with an air cylinder, Fig. 17, Plate 10. The hammer, of which a great number had been made, was used for forging horse-shoe nails. The date of the drawing was 1871.

Mr. E. J. CHAMBERS said he had had some little experience in the use of the Longworth power-hammer. In a weak moment, about five years ago, he introduced himself to Mr. Samuelson as one who wanted a Longworth power-hammer. For a long time he had been

* Proceedings 1858, page 118.

convinced that when a School-Board education had been given to most working people, there would not be many of them willing to work an oliver. He would say that oliver work, puddling, and mining, were very much on a par as regarded hard labour, and that no educated man would follow any of those occupations. Seeing as he did that the time would soon come when men would absolutely refuse to work olivers, he set to work to see how a machine could be made that would help to do away with that work, and after looking at other power-hammers he decided to give the Longworth a trial. He had had many an anxious night, not exactly a sleepless one, and many a worrying day, over that weak moment. Mr. Samuelson was quite right in saying that he, the speaker, had given repeated orders for these hammers. He had the first power-hammer five years ago ; where it was now he did not know. It was a wreck. But thanks to Mr. Samuelson's assistance, he had some more built embodying suggestions that Mr. Samuelson was good enough to accept from him ; and after working these, other suggestions were carried out, and a good deal of time spent in re-designing a special hammer, with the result that a very much better tool was obtained than the first. Mr. Samuelson would correct him if he was wrong, but he considered that a better tool was obtained, although not perfectly satisfactory to himself. It was a hammer that he would not give up, but he thought it was necessary to caution any of the members who wished to follow in his wake and use that hammer, that they must make up their minds to several things. First of all, the men it was desired to help by removing their hard labour would be the first to go dead against its adoption, and might probably arrange that the hammer should not do its work satisfactorily. The next thing was that partners, or foremen, or managers, would all say, "I told you so," when the hammer first broke. Then would come the real difficulties of the machine, the trying to make it do the special work. That had been his greatest difficulty. He might say that at the present moment he had no trouble with his men with the hammers, and he had fourteen of them at work. They were making, he thought, about 500,000 strokes a week each, that was 120 strokes a minute each. One great advantage about the hammers, which was

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not generally met with in steam-hammers, was that they only required one head to work them, and that need not be a very high-class head. It wanted a cool head, but it did not require more than one head. A couple of heating-boys were necessary. Some of the members would probably start with one boy, and if they listened to their men they would find that was all the hammer could do with. But if they made up their minds to have another boy, they would find a couple of boys could heat work nearly as fast as the hammer could forge it. But the difficulty he had had with the hammer was its want of adjustments. He was always begging Mr. Samuelson to put in some more adjustments, and Mr. Samuelson knew as well as he did the difficulty of those adjustments when the hammer was making 120 strokes a minute week in and week out—say 120 strokes, and perhaps half that number of blows, because a stroke and a blow were not the same thing with the power-hammer. It might be running light, and a certain amount of time must be given to getting the work fixed, but the number of blows was very great, and when the vibration was taken into consideration, first of all in the tools and then in the hammer-block and in the working parts of the machinery, it could be quite understood why he wanted adjustments. Mr. Samuelson had certainly made very great improvements. The upper cylinder had been brought down below. He had had one break off short and fall within about six inches of a man. As fast as he could he was going to alter his old hammers, of which he had half a dozen, into new. What he wanted Mr. Samuelson to do—and he had no doubt he had come there prepared to state he was able to do it—was to make more adjustments in the hammer, and to cure those defects. It could be well understood that a crank-shaft going at that speed, after about a month's wear, if it was working in bushes, would be subject to a great deal of play, and from the moment it began to play the hammer was knocking itself to pieces. It was those points that were so necessary to be seen to in a tool of that kind. This hammer was subjected to a much greater strain, to his mind, considering its form, than the steam-hammer. The steam-hammer had practically only its vertical stresses, whereas in the power-hammer there was the

rocking-bar and the crank-shaft, which were subjected to an immense amount of vibration, and those parts required to be improved, so that they could be adjusted and maintain their alignment. He hoped Mr. Samuelson would increase the mass in his further improvement of the Longworth power-hammer. He had no doubt that Mr. Samuelson would say that he (the speaker) wanted a 1 cwt. hammer to do a 5 cwt. work.

MR. SAMUELSON.—And at a 1 cwt. price?

MR. CHAMBERS.—That might be; but it was for Mr. Samuelson to make a tool which should have all it ought to have in it, and then he could say, "You can have this tool if you like at this price; if you would like to have one without these improvements you can have one at half the price." He might mention that he used the hammers for making spindles of various sizes, for the same purpose for which the old Ryder forging machines were used with oliver work, not bolt work. It might be applicable to bolt work, but for general forging of round light spindles he believed the tool was one of the best that could be used.

MR. J. A. BOORMAN said he had had some little experience with pneumatic-hammers, but not so much with the power-hammer which had been described in the Paper. He had, however, much experience with another power-hammer, and had found out several peculiarities which it had in common with other power-hammers. In the first place he thought that it was quite a mistake to assume that the power-hammer was going to displace the steam-hammer altogether. Both hammers had their uses. The use of the power-hammer, to his mind, came in more especially for swaging, planishing, and forging between dies. He had not yet seen a power-hammer which could strike a single blow satisfactorily. In the first Paper Mr. Samuelson claimed that that could be done with the Longworth power-hammer, but he thought that even with that hammer it could not be done in a very satisfactory manner. To strike a single blow of a light or heavy nature was of great

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importance in certain classes of work, and he did not think that any power-hammer at the present time was sufficiently sensitive to strike a single blow which could be said to be under absolute control. With regard to the economy of pneumatic-hammers, he did not doubt for one moment that they were very much more economical than steam-hammers. That had been proved over and over again. The same arguments which were used in the Paper with regard to the Longworth power-hammer equally applied to other power-hammers in that respect. But there was one point about the pneumatic-hammer where it differed very considerably from the steam-hammer, namely, that a single blow could not be struck, and the tup could not be allowed to come down on the work and pressure put upon it as could be done with the steam-hammer, when bending anything over the anvil block. But in a well constructed pneumatic-hammer, very light blows could be dealt, and gradually increased to the maximum blow desired to be struck. In some power-hammers the blows could be immediately stopped without the necessity of shifting the belt by simply taking the power off with the foot or the hand-lever. He might say he had not seen the Paper before that evening, and had not intended to take part in the discussion until unexpectedly called upon to do so from the chair, and there were some points in it which he should like to think a little more about.

Mr. WILLIAM REAVELL said that some little time ago he was contemplating putting down a hammer in his works, not a power-hammer of the Longworth type, but a steam-hammer of the ordinary type, worked by compressed air instead of by steam. His idea was that the principal losses with the steam-hammers were due to condensation. Perhaps Mr. Samuelson would be good enough to say whether he had applied to an ordinary hammer compressed air instead of steam.

Mr. SAMUELSON said that he did not claim for power-hammers an exclusive place in workshops. They were useful up to certain sizes, but not beyond, and he should not like the members to go away with

the idea that he thought a five-ton power-hammer was going to take the place of a steam-hammer.

Mr. E. J. CHAMBERS said a power-hammer would strike a single blow. Half a dozen strokes could be made in the air and then one down upon the anvil. The power of the blow could be varied by the pressure of the foot. It could certainly strike a single blow, but not so easily as with a steam-hammer.

Discussion on 22nd March.

The CHAIRMAN, to put the meeting *au fait* with the nature of the discussion at the preceding meeting, referred to the Longworth Power-Hammer. He pointed out that it was driven by a belt, and that the shaft which drove the belt could be electrically driven, or driven in any other way, so that in that sense it could be an electrically-driven hammer. The crank at the back rocked a rocking bar which took hold of the two long connecting-rods, but was not coupled directly with the ram of the tup. It took hold of an air-cylinder which contained a piston with a certain amount of play between the rings of perforation, so that there was lost motion between the cylinder and the ram. That, of course, was necessary to allow for the tup coming in contact with the thicker piece and avoiding breakage of the mechanism, and probably also it improved the blow by the elastic start which the air at the top of the cylinder gave it. At the lower part of the ram, as would be seen from the diagram, there was another piston working up and down in a fixed cylinder which had a number of air-ports in it, which could be all closed, or any number left open. If the whole of them were closed, the compression of air in the bottom cylinder arrested or tended to arrest the motion of the tup, and prevented it striking down so close to the anvil, or striking an unnecessarily strong blow. The discussion was opened a month ago, when Mr.

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Chambers had stated that he had used a great number of these hammers in place of olivers, and had used them with very great advantage (page 107). They would work very rapidly, up to 180 blows a minute. Mr. Chambers also suggested that adjustment to the joints would be a very good thing, because they were worked very hard, and got a certain amount of play. He, the Chairman, thought there was scope there for good mechanism, but if these adjustments were not very carefully designed he had no doubt the remedy would be worse than the disease.

Mr. C. LIDDELL SIMPSON said he should like to say one or two words about the way the power of the hammer had been reckoned. Anyone who had noticed a steam-hammer would find that it ordinarily made a very short stroke, so that to make a proper comparison of the power exerted by a steam-hammer, this ought to be taken into account. As far as he followed Mr. Samuelson's Paper he did not think that had been done. If the economical working of the power-driven hammers were to be compared with steam-hammers, the steam-hammer exhaust should be either led into a heater or taken into a condenser. Quite recently in his works he had gone into the question of replacing one of the hammers, and he studied the question as to whether it would pay him to put down a power-driven hammer as against a steam-hammer. The only thing that stopped him putting down a power-driven hammer was that the work of his firm was very intermittent and of varied nature, and that power-hammers would not stretch, and the steam-hammer had a greater capacity and was better adapted to the sort of work he had in hand. Another point about the steam-hammer was, that in order to get the best results it was necessary to have small steam-pipes laid to it, and to use if possible superheated steam. When a hammer was treated in that way it was not quite so uneconomical as it at first appeared.

Mr. LESLIE RADCLYFFE said that the "Player" hammer differed from the "Longworth" in taking the power direct from the main crank and not through levers, as would be seen by Fig. 18, Plate 10.

The hammer was driven by means of a crank which worked with a gun-metal block in a steel banjo; the bottom part of this banjo acted as cylinder cover and was bolted direct to the cylinder itself, and driven up and down by the crank, being guided by slides in the main frames. The tup or hammer-head was fastened to the bottom of the piston-rod, and all power transmitted through the crank to this tup by the top or bottom cushion of air in the cylinder. The force of the blow was governed by varying the amount of air-cushion above or below the piston, by means of a series of holes drilled in the cylinder at various heights. The inlet and outlet of air was governed by a valve as shown on Fig. 18 (controlled by means of hand or foot-gear) for opening any one of these holes at will, but only permitting one hole to be opened at one time, thus providing a means of escape for the air. Thus, by having one of the lower holes open, only a small cushion is formed under the piston, and a heavy blow is obtained; if a higher hole is open, one gets a deep cushion and a smaller blow, or the tup may be held off its work altogether. He had found from experience that through the simple construction and few parts 4 B.H.P. was sufficient to drive a 3-cwt. size hammer at 200 revolutions per minute. He used a 24 inches by 4½ inches pulley with a 4 inches single belt.

With regard to Mr. Simpson's remarks (page 112) about the economy of the power-hammer, it greatly depended on the work to be done, but it was certain that there was no economy in giving light blows with a steam-hammer, whereas with a power-hammer one could give a great number of blows to the same work than with a steam-hammer in the same time and with economy, inasmuch as 75 per cent. of the light blows given by the power-hammer would have to be done by hand and the other 25 per cent. by the steam-hammer. The power-hammer was cleaner, and the amount of work done was directly in proportion to the power used; it could be controlled in the same manner as the steam-hammer, and if only manufacturers would ascertain exactly what the hammer was to be used for, there was no reason why any trouble should follow the purchase of a power-hammer. He did not recommend a power-hammer larger than 10-cwt. size.

The CHAIRMAN asked for how many strokes a minute the hammer was made.

Mr. RADCLYFFE said they were worked up to 500 for the small riveting hammers weighing about 1 lb. The 3-cwt. hammers made 260 revolutions a minute.

Mr. SAMUELSON, in reply, said that in bringing forward the Paper at the request of the Institution he really wished to point out the advantages of pneumatic as against steam-hammers, but only up to certain powers. He did not wish to infer that power-hammers were going to take the place of steam-hammers entirely, as some members who had spoken seemed somewhat inclined to think. Practically speaking he did not think there was a useful power-hammer made at present over 10 cwt., and to hammers of that size and under he would desire the members to consider that he had confined his remarks, and the claims that he had made. Taking firstly Mr. Simpson's question (page 112), he could hardly understand what he said at first, except that he compared the strokes of the hammers and the consumption of steam, and that the steam-hammer was sometimes running light. In the figures given in the Paper he had given the hammer at its heavy stroke, as he thought it was the fairest comparison to make, when both the hammers were doing their utmost work, and he compared the water consumption in the engine driving the power-hammer with the steam consumption in the steam-hammer. With regard to Mr Radclyffe's remarks (page 112), Mr. Radclyffe had introduced a subject which he carefully avoided touching upon, namely, the comparison of various makes of pneumatic-hammers. He thought that better left for discussion outside the Institution. His old friend Mr. Chambers had been somewhat inaccurate. Mr. Chambers received his first power-hammer seven years ago, not five: he had had it for three years before ordering others, and would not let him (Mr. Samuelson) see the work to be done; he tried to ride a steeplechase on a donkey with only partial success. Mr. Chambers also made the remark (page 107) that the hammer, when it was returned, was a wreck. He, Mr. Samuelson, repaired that hammer

in 1896, that was after four years' use; he put it into good working order, and sold it to another firm, who were going to run it for ten hours continuously every day, and a week or two ago they asked him for a small repair part to put into the hammer. That was Mr. Chambers' wreck! There was a great secrecy about their work, but he had subsequently found out that Mr. Chambers had been putting the hammers to very severe tests which general users of hammers did not put them to, namely, he had been working on both sides of the hammer tup alternately, as well as in the centre. That answered Mr. Chambers with regard to wear and tear. All the adjustments that Mr. Chambers had asked for had been given to him, except one, which he had only just now found out to be necessary. If Mr. Chambers liked to suggest any more alterations or improvements he should be only too glad to embody them.*

Another remark made at the last meeting was by Mr. Boorman (page 109), who said that single blows could not be given with the hammer. Mr. Chambers very kindly stepped into the breach and said they could, and he himself emphatically confirmed that. With the Longworth hammer the regulation of the blows was exceedingly delicate, and they could be regulated with a very little practice as easily as in striking single blows with the steam-hammer. Mr. Reavell had asked (page 110) whether any experiments had been carried out with compressed-air in steam-hammers. His answer to that was that they had not, and he thought it was rather beyond the question.

Communications.

Mr. DAVID JOY wrote that in 1871 he had made a considerable number of pneumatic power-hammers for forging horse-shoe nails. This hammer was shown in Fig. 17, Plate 10. The tup and air-cushioning piston were actuated through a wood-spring lever by means of a crank driven by a belt, and these hammers struck about

* Mr. Chambers had now sixteen of these hammers, either at work or on order—June 1900.

(Mr. David Joy.)

500 blows per minute. It is worthy of note that the practical success of this hammer depended on the employment, after many experiments with steel, of wood for the spring lever. Whilst the former reached a cost of 35s. per spring, and often failed within a week, the wood, after a little experience in getting the most suitable material (ash) and the right proportions, cost 2s. 6d. each, and lasted up to three months.

Mr. GEORGE R. PHIPPS wrote that a friend of his was working his steam-hammer in London by compressed air, and considered the result obtained was better than when it was worked by steam, as the cylinders kept cool, and there was no leakage from the glands. His gas-engine worked an air-pump, getting a pressure of 60 lbs. per square inch in his disused steam-boiler; the pipes &c. from boiler to hammer were the same as when using steam, and he stated that economy was obtained by this method.

Mr. SAMUELSON wrote that, whilst his figures given in respect to the power absorbed by the 3-cwt. hammer erred on the side of over-estimating rather than under, he had given in the Paper maximum figures from the diagrams taken in his tests, other cards and figures showing much less power.

In further reply to Mr. Simpson's remarks (page 112), he desired to point out, as he had stated in the discussion (page 114), that his comparison between a steam and power hammer was taken when both were giving their heaviest blow, but that the diagrams and figures on Plate 9 also showed the economy in the necessary driving power, when the power-hammer was running light. It was hardly necessary for him to point out that, whilst Mr. Simpson advocated the use of a condenser, or a superheater, being used in conjunction with steam-hammers, there were few users who would for one minute consider the considerable extra cost of such a plant for such a purpose, and that steam-hammers had necessarily in many instances to be placed at very considerable distances from the boiler. There were no doubt special cases, such as Mr. Simpson's, where users of this class of tool would not find the same economy as others in the

use of power-hammers; whilst on the other hand, where continuous work, or difficulty of carrying steam to hammer ensued, the advantages of a power-hammer were obvious.

In reference to the remarks made by Mr. Radclyffe (page 113), whilst not desiring to discuss the comparative values of the various pneumatic hammers in use, he thought that he might be allowed to draw the attention of the members to the great similarity in the design of the Longworth hammer (one of the vital principles of which was its perfect control of the blow by means of air-ports in the bottom cylinder) to that hammer which Mr. Radclyffe referred to. In smaller sizes of the Longworth hammer, a similar form of drive was employed to that used in the "Player," but for the larger sizes he considered the other form as described as being preferable, on account of the lines of force, or action, being kept approximately in a direct line with the centre line of piston-rod, thus obviating practically all tendency to side strains. Whilst Mr. Radclyffe had claimed a fewness of parts for his hammer, he did not point out the more intricate arrangement of valve-gear for controlling the blow, and the additional links, pins, etc., which would be apt in time to become loose, and rattle, and thus to interfere with the delicacy of adjustment in the blow. Further, that whilst the calculation of B.H.P. given by Mr. Radclyffe was taken merely from the diameter of pulley and speed of same, if a similar calculation were made of the 3-cwt. Longworth hammer, it would be found that the same result would be arrived at, and the power given would be nearer 4 B.H.P. than that taken from the diagrams, besides which it would have been interesting possibly to the members to have had a comparison of the work done under the "Player" 3-cwt. hammer and the Longworth, and the net falling weight given of the tool in question.

He also desired to add, in reply to the Chairman's following question (page 114) as to the number of blows per minute for these hammers, that the Longworth hammer was also capable of being varied in design to give as many as 500 blows per minute, down to the number suitable for general forging work, say 130 to 150, and less. This could be verified from the diagrams, from which the

(Mr. Samuelson.)

revolutions of some of the various types of the Longworth hammer were specified, but he considered 260 blows per minute for a 3-cwt. hammer used for general forging purposes was too rapid for a smith to handle his work comfortably under the tool.

LONGWORTH POWER-HAMMER.

Plate 4.

1-lb. Riveting Hammer.

Roller Chain
Riveted by Hammer.

3-cwt. Hammer.

Plate 4.

Gearing for 3-cwt. Hammer.

Fig. 2. *Section.*

Mechanical Engineers 1900.

LONGWORTH POWER-HAMMER. Plate 6.

3-cwt, Single Standard, Self-contained Hammer.

Fig. 3.

Fig. 4.

Suitable for
General Forging.
Scale $\frac{1}{32}^{nd}$

Fig. 5.

Acceleration of Actuating Cylinder
due to position
of Crank and Rocking Lever
of above Hammer.

Scale $\frac{1}{8}^{th}$

LONGWORTH POWER-HAMMER. *Plate 7.*

450 Revs.
per min.

1-lb. Riveting Hammer.

Fig. 6.

Fig. 7.

Scale
 $\frac{1}{6}^{th}$

Stroke 2 inches

wrought steel

Stirrup for foot

20-lbs. Planishing Hammer.

Fig. 8.

Fig. 9.

Stroke $2\frac{1}{2}$ to 10 inches

250 Revs per min.

Scale $\frac{1}{24}^{th}$

LONGWORTH POWER - HAMMER. *Plate 8.*

1-cwt. Hammer for Tube Welding.

Fig. 10.

Fig. 11.

Hammers for Stamping and General Forging.

Fig. 13. 7-cwt.

Fig. 12. 3-cwt.

LONGWORTH POWER - HAMMER. Plate 9.

Fig. 14. Diagrams of Steam-Engine. Cyl. 11" diam. 10" stroke. 205 revs.
Driving 3-cwt. Hammer.

Fig. 15. Diagrams of 3-cwt. Hammer. 132 blows per min. 368 lbs. falling weight.
Driven by above Engine.

Actuating Cylinder 9 $\frac{1}{4}$ " diam. Controlling Cylinder 11 inches diam.
Top of Piston. Bottom of Piston.

Fig. 16. Diagrams of 4-cwt. STEAM-Hammer (420 lbs.)
Cyl. 8" diam. 16" stroke. 120 blows per min. 10 I.H.P.

Fig. 17.

"Joy" Hammer, 1871.

For making Horse-shoe Nails.

Fig. 18. 3-cwt. "Player" Pneumatic Hammer.